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SAN FRANCISCO'S

WATER SUPPLY AND SEWERAGE

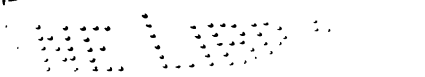
BY

CHARLES N. ELLINWOOD, M. D.

WITH ILLUSTRATIONS OF
THE SPRING VALLEY WATER WORKS

LECTURE AT COOPER MEDICAL COLLEGE

February 16, 1900



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SAN FRANCISCO'S

WATER SUPPLY AND SEWERAGE.

The civilized world has awakened to the fact that a bountiful supply of pure water is an essential factor in man's existence.

Populous cities, tribes and races of men, have, in the evolution of time, arisen and occupied prominent places in history; and their passing, leaving only dim tracings of their existence, has been a mystery only solved in these latter years by the study of disease and the triumph of medical science in the discovery of the causes of infection and the methods of its propagation and dissemination.

We wonder in amazement that the sacrifice of so many millions of lives in the plague-spots of the world should have been repeated age after age and yet the mystery remain unsolved; that only to-day are man's invisible foes revealed and their vanquishment made possible.

To this end a great war has been inaugurated, the most humane, the most comprehensive in its inception, the most beneficent in its results. It commands the alliance, offensive and defensive, of all governments and of every people of the world, on one side; and on the other, man's destroyer, disease germs, which infest the atmosphere, the water and food products on which man's life depends,— a gigantic battle-field extending over the earth's surface—a battle involving in its issue more lives

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THE TOP OF CRYSTAL SPRINGS DAM—SHOWING THE METHOD OF BLOCKING.

than have been sacrificed in all other battles since the beginning of time.

There is now an organized effort being made by an organized army of scientists and humanitarians of North America to prevent the pollution of the surface water of streams, rivers, and watersheds, by stopping the pernicious practice of flowing sewage upon them.

Sanitary legislation is being asked of our Government at Washington and also of the Government of Canada for the suppression of this growing evil, by which many thousands of lives are being sacrificed, and the gravity of the situation is increasing daily, even jeopardizing the most populous regions of the continent.

The problem is presenting itself on a large scale at the present moment, by the opening of the Chicago canal, by which the entire sewage of that great city, thousands of tons daily, are carried into rivers flowing into the Mississippi River, on which great stream St. Louis and many other cities depend for their water supply for domestic and other uses.

Millions of dollars have been spent by Chicago in the construction of this great sewer canal, of incalculable benefit undoubtedly to the denizens of Chicago, but of incalculable destruction to those unfortunate inhabitants living on the banks of the rivers receiving this pollution, all the way down to New Orleans.

The State of Missouri questions the right of her neighbor, the State of Illinois, to send her filth down the stream to her, and the General Government is called upon to abate the nuisance.

The same problem is being presented in nearly all the rivers of this continent, and also in Europe as well.

As the population becomes more dense the pollution of the water by sewage increases, and those cities which are dependent upon rivers and public waterways for their supply of potable water, suffer from the contamination as

THE CRYSTAL SPRINGS DAM — SHOWING OVERFLOW.

a consequence. The sewage from towns, cities, camps and aggregations of people and of animals is the great factor in that virulent pollution of water, carrying with it the germs of disease and death.

It is to be hoped that some efficient ways and means may be found to overcome this great obstacle to human progress and longevity.

The organization of the American Water Works Association is a very promising effort in that line of research and experiment. Guided by men of eminent abilities and philanthropic motives, it is believed that they may arrive at the practical solution of this great problem.

Water, as we find it in nature, is never pure. It is contaminated by impurities derived from the air in which it floats as cloud and through which it falls as rain, and from the rocks and soil over and through which it passes on its way to the streams; but these impurities, if unmixed with decay and sewage, are usually harmless to man.

Rain water contains but a small portion of mineral matter with a considerable proportion of organic matter.

Upland surface water or mountain water contains a much larger proportion of both mineral and organic matter, the mineral water differing greatly in different localities by reason of the varying geological formations of the watershed, the nature and amount of mineral impurities depending upon the soluble constituents of the rock. Shallow well water is contaminated by the greatest amount of impurities of both organic and inorganic matter, as such wells are dug for convenience near the dwellings they are intended to supply, and naturally get the seepage water as it percolates through the soil, carrying with it the mineral, and also the organic matter, vegetable and animal, undergoing decomposition and solution.

Such shallow well water is usually bright, clear and sparkling, and also palatable, but, alas, is most apt to carry pathogenic germs of disease, such as typhoid fever,

THE CRYSTAL SPRINGS DAM — AS SEEN FROM THE LAKE.

and should be avoided whenever possible. In deep wells, say of a hundred feet or more, the organic matter disappears practically from the water by a process of oxydation and purification as it slowly filters through the great depth of earth.

San Francisco is greatly favored in its water supply, if we make a comparison with that of other large cities of the world. I am not unmindful of the occasional objections, and even loud complaints, against Spring Valley water. Such complaints were formerly much more common, and deservedly so, than now. But before I tell you what I have seen of the water, and the sources of the water which the Spring Valley Water Works supplies to the people of this city, let us take a rapid glance at the conditions of the water supply in other cities.

In the numerous reports of the Royal Commissioners of the Water Supply of London I find some interesting facts, viz : In 1581 Peter Moreys obtained permission to build a water-wheel under one of the arches of London Bridge, to supply a portion of the city with water, and the pumps were operated by the tides. For about 200 years, a considerable supply of water was obtained in this way, pumped from the Thames River at London Bridge.

Of course, the water at that time could not have been such a terribly polluted stream as in these latter times, or London would not have survived with such a water supply. But even now the great question of a pure water supply for that metropolis is not satisfactorily solved, and only a scant quantity of impure water is furnished to its inhabitants.

The city of Berlin gets its water from the River Spree, which has become so polluted by sewage from the populated districts on its watershed that 80,000 to 90,000 micro-organisms can be counted in a cubic centimeter (fifteen drops) of its water, and recently I have seen it

THE SMALL LAKE MADE BY THE STONE DAM
BELOW PILARCITOS LAKE.

stated that a process of sterilization has been resorted to at Berlin by which the water is forced over a series of small falls for aeration, and during the passage it is subjected to a current charged with ozone. Ozone is oxygen in an active state, which destroys, by oxygenation, the micro-organisms to such an extent as to render the water potable.

Hamburg, but a short time since, suffered from a frightful epidemic of cholera from its polluted water supply, due to the flow of sewage into the river which the inhabitants were obliged to use.

Philadelphia has in the past two or three years lost more valuable lives from typhoid fever and at greater cost to the State and Nation than has been sustained by our Spanish war, and all this simply by the sewage pollution of her water supply.

New York, New Orleans, and Washington even, are struggling with this same impending danger of infection from their water supply.

Chicago, if I may be allowed to again refer more particularly to her canal, has spent $33,000,000 in the construction of a drainage canal to divert from the city its sewage and to remove from its water supply this potent source of pollution. This is the largest sanitary enterprise which has ever been completed in the history of the world.

This drainage canal is 160 feet wide at the bottom and is 38 feet deep, and will carry all the sewage which flows from the city into the Chicago River, and which has heretofore remained there or flowed into Lake Michigan. Now, through this great canal it will pass down by natural waterways to the Mississippi River. The water flowing through this canal from Lake Michigan through the Chicago River is said to be 10,000 cubic feet per second, which is about five per cent. of the amount of water flowing through the Niagara River, and is sufficie1

THE STONE DAM.

to raise the low-water mark one foot in the Mississippi River at St. Louis.

This gigantic enterprise must vastly improve the sanitary conditions of Chicago, and save yearly thousands of its inhabitants from preventable diseases and death, serving the two all-important purposes of removing all the sewage from the city and also permitting the supply of reasonably pure water from Lake Michigan contiguous to their intake pipe.

But while this achievement is such a boon to Chicago, yet St. Louis is a sufferer by having this immense amount of Chicago sewage added to the already polluted water of the Mississippi River, from which stream her water supply is drawn. Of course many other cities along the Mississippi are equally interested with St. Louis in this question, and the courts of justice are being called upon to settle it, and it may be in the end that engineers will find a way to flow this now dreaded sewage waste on to tillable lands, to fertilize them, to keep them ever productive, and in such a way as not to pollute the natural waterways of the continent.

After this cursory survey of the subject in general, let us look at home, for our individual interests and welfare. My inquiries and study of San Francisco's water supply have astonished me with the fact that very few people, comparatively, manifest any particular interest in the subject other than the financial side of it.

Through the courtesy of the officers of the Spring Valley Water Works I have been able to view, aided by intelligent guides, the various and extensive watersheds and works by which this city is well supplied with good, wholesome water, free from all such sewage pollutions as many cities suffer from, situated on navigable rivers, or getting their water supply from such a source.

The growth of the water-works on this peninsula, from a small beginning in 1854 to its present gigantic and

SUBTERRANEAN WATER DEVELOPED AT SUNOL.

perfected establishment, is truly a marvel in the history of such enterprises, and reflects honor upon its promoters, for their far-seeing wisdom, courage, and skill.

The operations of the water company in the storage of water for the city commenced with Pilarcitos reservoir, and one after another San Andreas, Crystal Springs, and Lake Merced were acquired. Their watersheds cleared as far as possible from contaminating causes, and extensive, solid, and admirable works erected for the economic storage and distribution of the water so provided for, and to which system has been added in these recent years that very important acquisition of that vast watershed, the area of which extends from Mt. Hamilton to Mt. Diablo, which yields a generous flow of clear, sparkling, well-filtered, and consequently pure water at Sunol, where it is protected from surface water contaminations and thence conducted in permanently established flume and pipe lines directly to the company's reservoirs in this city.

My excursion to Lake Merced, a few weeks ago, was a delight and a surprise to me. Common report has always been adverse to the availability of Lake Merced as a source of our water supply, and I am free to confess that I fully sympathized with that sentiment from personal observations made some years ago in trying to get around, over, or through the salt marshes or sloughs, where hogs were wont to wallow in the bordering territory of this lagoon. Then it was a filthy pool collecting the decaying organic matter from the peninsula of which it was a receptacle and at high tide getting an inflow of salt water from the sea, conditions well calculated to make a lasting impression of the non-potable character of Lake Merced water. But now how changed!

By the fortuitous combination of two all-important events the water of the lake has become a large and important source of our water supply.

SUBTERRANEAN WATER DEVELOPED AT SUÑOL.

First—The Pacific Ocean, during the past few years, has kindly washed up from the beach its golden sands, and aided by the summer winds a perfect barrier has been built against the inflowing salt water from the sea, and thus that source of impurity has been removed.

Second—A threatened water famine in 1877 convinced the Spring Valley Water Works that this water must be utilized, and so at great expense and engineering skill it constructed drainage canals, by which the polluting surface filth is entirely diverted from the lake by a long brick aqueduct and tunnel and carried directly to the ocean.

The company now owns and can forever control this large area of watershed, and these circumstances have transformed Lake Merced from a filthy pool of a salt marsh and lagoon, which it formerly was, into a very important source of the good potable water supply of our city, comparing favorably in the recent analysis made by the Board of Health with the other sources on the peninsula.

With the experience gained at Lake Merced, the successful diversion of surface impurities from flowing into and polluting the water of the lake illustrates the practicability of applying the same methods to all the many hundred square miles of watershed now owned or controlled by the Spring Valley Water Works, and its ability to furnish an abundant supply of potable water for a million or more of thirsty inhabitants.

The recent acquisition and development of the immense watershed in Alameda County is, to my mind, the most interesting and admirable crowning work of the Spring Valley Water Works. To the penetrating vision of its engineer, Mr. Schussler, is due the discovery of a large subterranean lake, fed by hundreds of square miles of tershed, which has been successfully tapped at Sunol, d from which a large flow of delightfully pure water is seen to issue from its deep gravel formation.

This subterranean lake is secure from sewage pollution and capable of being drawn from at the will and skill of the engineer as the wants of the city may demand.

We look with wonder and admiration at nature's handiwork in providing these beautiful hills and valleys, so marvelously adapted to the purification and storing up a generous water supply in such close proximity to our favored city.

Mother Nature, in all her kindness and with such fostering care as no human forethought could have devised, has so planted these hills and so arranged the substrata of the valleys as to conduct to a secure and safe reservoir the falling rains from cloudland and have them there at the command of man, ready to serve his most beneficent uses.

The experience of the past years has convinced the presiding intelligence of the Spring Valley Water Works that it should have a storage capacity equal to a three years' water supply. The immense watershed, embracing the hills and valleys, reaching from Mt. Diablo to Mt. Hamilton, added to the several lakes and numerous reservoirs in the city proper and in San Mateo County, enables it to secure and hold, beyond peradventure, an ample supply to meet all necessities of the city and avert all danger of a water famine.

To be convinced of the capability of the Spring Valley Water Works to collect and impound an immense store of water for its future wants one need only to spend a few days in exploring the hundreds of square miles of watershed which the company owns and controls, embracing the hills and valleys of a large portion of Alameda, Santa Clara, and Contra Costa counties, and the extensive watersheds on the peninsula which can be made tributary to the Crystal Springs, San Andreas, Pilarcitos, and Merced lakes. And finally, its distributing reservoirs, nine in number, so unobtrusively located in the various sections of the city, and so quietly doing their beneficent

SHOWING FILTER PIPES, SUBTERRANEAN AQUEDUCTS AND GRAVEL FILTER IN PREPARATION.

work of receiving, holding and giving out their many hundreds of millions of gallons of water just whenever we hundreds of thousands of people open our little faucets and get an ample supply of water, always ready, to meet our necessities.

These immense reservoirs are so wisely planned and placed at the various necessary altitudes that they supply the various districts of high hills and low lands of the city under a pressure equal to all emergencies, that of extinguishing fires and flushing sewers being of great importance.

It may not be known to many of you how the quality of our Spring Valley water is improved and purified by its manipulation, by screens and aeration processes and the agitation and pressure to which it is subjected in traveling its many miles of pipes and conduits before it reaches the consumer.

But such is the interesting fact, and without going into any tedious details let me give you a single example of the many scientific observations which have been made to determine this, and which show that the more constant the agitation and aeration to which the water is subjected the freer it is of the contamination called bacteria; e. g., water taken from the San Andreas lake after it has passed through a screen which removes some of its vegetable matter, yet contains 1640 colonies of bacteria to the cubic centimeter, or 15 drops.

Now, if we follow this water from San Andreas we find that it flows through a thirty-inch pipe sixteen miles long and is subjected to a 340-foot pressure, and on arrival at the College Hill reservoir it has lost one-half of its bacteria ; i. e., leaving only 800 colonies in the cubic centimeter ; and finally this water undergoes a further process of aeration, by which its bacteria are again reduced, leaving only 290 colonies in the cubic centimeter.

HOLDING PIN, SHOWING FIBRE IN THE CONCRETE, SUBTERRANEAN AQUEDUCT.

The same results are obtained in the microscopic tests of all the reservoirs of the company ; i. e., there is a constant diminution in the bacteria as the water is subjected to the purifying processes, a result which is very desirable—for while a few of these innocent bacteria are by no means injurious and should not deter us from drinking plenty of water, yet as an exclusive diet we might find valid objections.

Water drawn from the faucet in Cooper Medical College laboratory shows from 300 to 400 bacteria in the cubic centimeter, and this is a fair average of the purity of water throughout the city, and compares very favorably with the water supply in the most favored cities in the world.

These observations were made by the Board of Health, and published last month. Their analyses show that the purification of the water from this vegetable growth in its transmission from San Andreas to College Hill is accomplished to the extent of the difference between 1640 at the lake to 290 at the reservoir.

Still further improvements can certainly be made, and are now engaging the earnest consideration of the water company, which will find, I believe, the final solution of this difficulty in the removal of all vegetable growth from the watershed, as far as possible divesting it of decaying leaves, grass and shrubs, which now furnish the pabulum for the growth of those numerous algæ you observe in the still water of the reservoirs, and notably in the water-tanks of our city houses.

If it is possible, in other words, to protect the watershed from the decay and solution of vegetable growths, we render the water safe from further contamination by impounding it in the lakes, or its storage in our reservoirs and individual water-tanks.

The analyses of the water from all the sources of supply of the Spring Valley Water Works show a remarkable

LAYING SUBMARINE PIPES ACROSS THE BAY OF SAN FRANCISCO, FROM DUMBARTON POINT

absence of all pathogenic organisms or specific disease-producing germs, like typhoid or tubercular bacilli, from which we find that we are perfectly safe in drinking Spring Valley water, and, in fact, I believe the average of city residents, people of sedentary habits, generally, ought to drink more water than they do.

The suggestion here presented of how best to prepare and protect a watershed from contaminating causes is one of incalculable importance when you consider the consequences of neglect which may jeopardize the health and lives of a million people. The solicitude of the water company is alive to this problem, and I feel assured that every precaution will be taken to keep the water pure and free as possible from all harmful contaminations.

The microscopic examination of the water from the subterranean lake, at Sunol, shows only twenty to forty bacteria to the cubic centimeter, which is the most remarkable instance of a natural water in all its purity that I know of, and this freedom from organic matter is undoubtedly due to the perfect filtration to which it is subjected in reaching and passing through the subterranean gravel formation.

CALAVERAS RESERVOIR, PROVISION FOR THE FUTURE.

Looking far ahead to the time when San Francisco shall have a couple of millions of inhabitants to be supplied with water, the Spring Valley Company has secured another site for an artificial lake, the Calaveras reservoir, some ten miles south of Sunol, with a watershed of 140 square miles tributary to it, which is estimated to yield 30,000,000 gallons in all ordinary years of rainfall.

The elevation of the outlet of this auxiliary reservoir, as planned, will be 600 feet above tide-water and fifty miles from the city, so that nearly the whole city can be supplied from it by gravitation, or its water can be made

SHOWING THE CONNECTION OF MILLBRAE PUMPS WITH THE 44-INCH CRYSTAL SPRINGS MAIN.

to gravitate into San Andreas and Crystal Springs Lakes, situated on the peninsula about twenty-five miles south of San Francisco.

Thus it will be seen that the water supply of San Francisco is, happily, well provided for in ample quantity and of vastly superior quality to that of other cities of this continent, and of Europe as well, where usually their water supply is drawn from navigable streams, with a dense population on their watersheds, polluting them by draining their sewage into the passing current.

So far our investigations justify the conviction that by the co-operation of the rainfall, the watershed, and the impounding capacity of the Spring Valley Water Works, San Francisco is generously provided with water for all present needs, and a liberal provision has been made to meet its further demands.

PER CAPITA DAILY CONSUMPTION.

About eighty gallons per day per individual is the present consumption of water, which, if necessary, could be reduced by stopping waste and extravagant use to one-half that per-capita allowance, and so insure an ample supply of potable water for two millions of people.

A further economy of our potable water supply has been with much good reason suggested in connection with the construction of the new system of sewerage which has been recently provided for by a popular vote, and which it is hoped may soon materialize.

If in that good work it can be so planned as to utilize the salt water from the sea for the flushing of sewers, the extinguishing of fires, the sprinkling of streets, and for private and public baths, then certainly a great saving of the potable water in the reservoirs can be accomplished thereby.

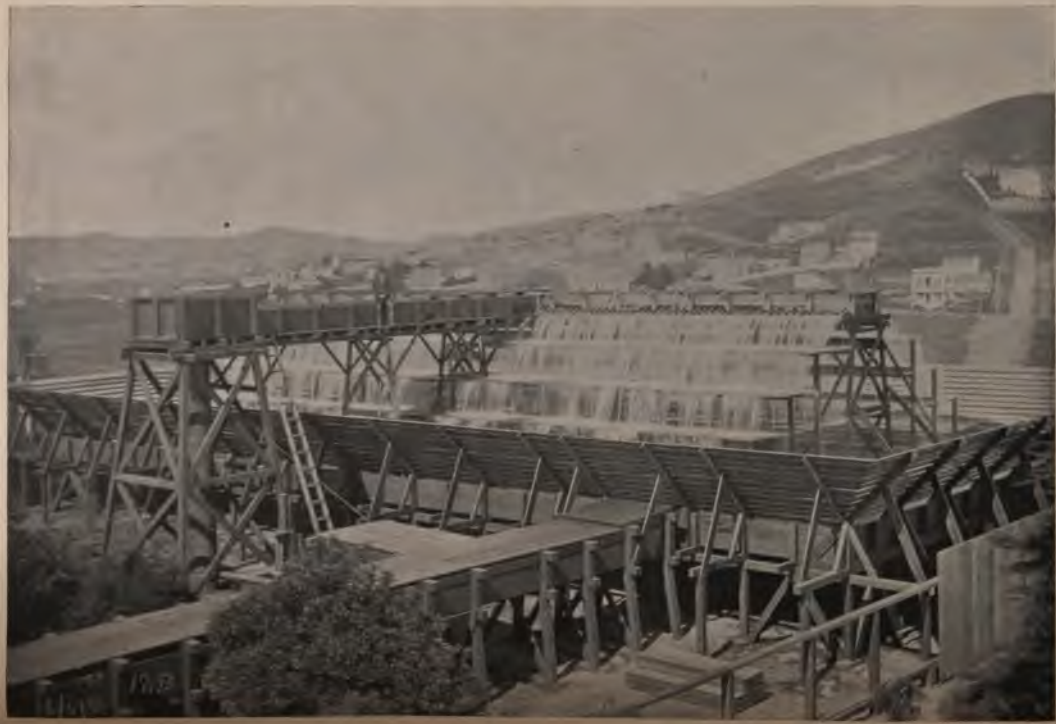
For sanitary considerations, as well as for the economy of our potable water supply, it is believed that the intro-

SHOWING DETAILS OF AERATOR AT COLLEGE HILL RESERVOIR.

duction of salt sea water will add to the efficiency of the sewers in forever ridding the city of North Beach nuisances, the Butchertown stench, and all such filth accumulations and causes of preventable diseases.

It is truly an outrageous criminal negligence that this city, so favorably located for perfect cleanliness and sanitation, should have been allowed to struggle on through all these years with filth diseases and a preventable mortality at such great cost of life and money.

The proposed new sewers, constructed on modern principles, common sense, and integrity, will, I trust, give us a pure atmosphere to breathe and more years to live, and oblige us to thank our lucky stars that our lot has been cast on this particular shore of the great Pacific Ocean.



GENERAL VIEW OF AERATOR AT COLLEGE HILL RESERVOIR.

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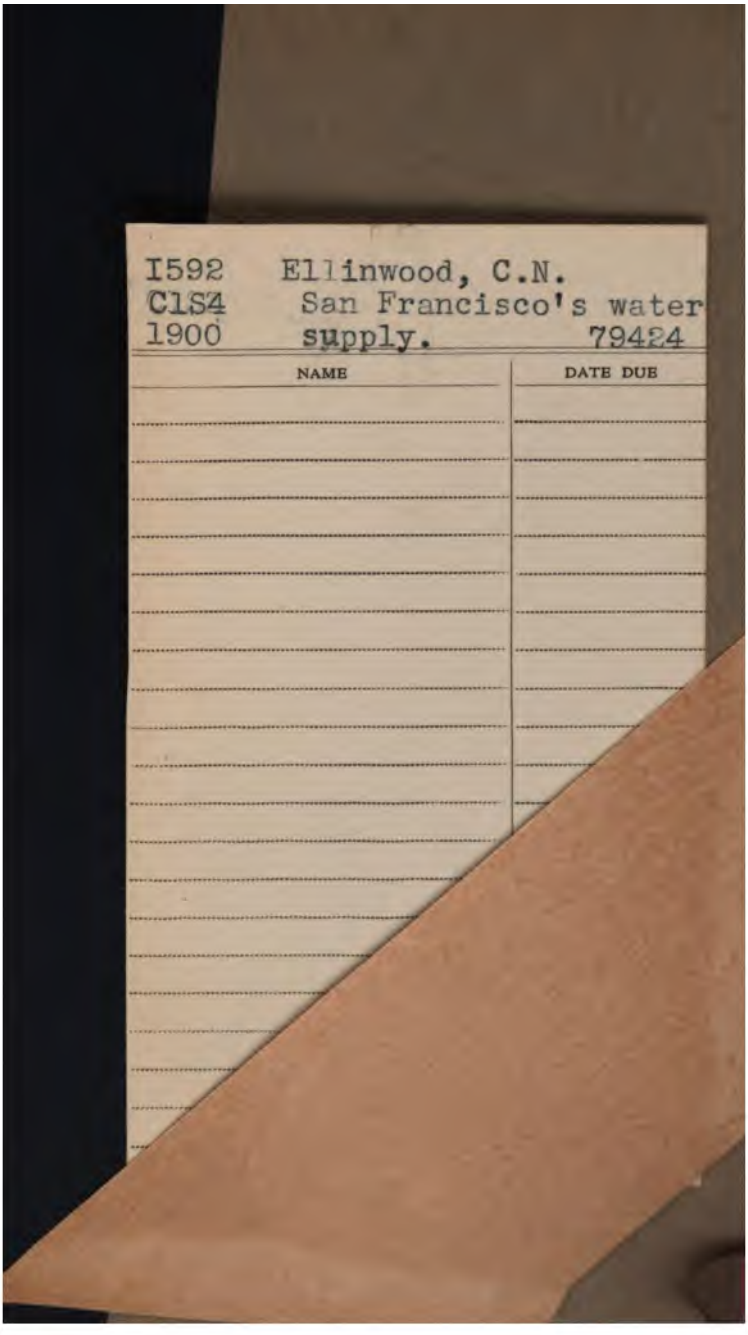

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